

Parasitoids and Diseases of the Elm Spanworm

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Abstract: Nine previously unreported primary parasitoids and possibly one hyperparasite were isolated from the elm spanworm, *Ennomos subsignarius* (Hübner) (Lepidoptera: Geometridae), during an outbreak in Connecticut in the early 1970s. Primary parasitoids included *Ablerus clisiocampae* (Ashmead) (Hymenoptera: Eulophidae), *Apanteles murtfeldtae* Ashmead and *Meteorus* sp. (Hymenoptera: Braconidae), *Aphanistes* sp. and *Phaeogenes mellinus* (Provancher) (Hymenoptera: Ichneumonidae), *Brachymeria intermedia* (Nees) (Hymenoptera: Chalcididae), *Muscina stabulans* (Fallen) (Diptera: Muscidae), *Boettcheria cimbicis* (Townsend) (Diptera: Sarcophagidae), and *Winthemia* sp. (Diptera: Tachinidae). *Astiphromma pectorale* Ashmead (Hymenoptera: Ichneumonidae), possibly a hyperparasite, was recovered from one pupa. Incidence of parasitism of these and other parasitoids along with the chronological appearance of the more abundant larval and pupal parasitoids is presented. A review of all reported parasitoids and diseases of the elm spanworm is given.

INTRODUCTION

The elm spanworm, *Ennomos subsignarius* (Hübner) (Lepidoptera: Geometridae), reached outbreak levels over large acreages of woodland in Connecticut between 1970–72 (Anderson and Gould, 1974), but ultimately the outbreak collapsed primarily because of parasitism by the egg parasitoid, *Ooencyrtus ennomophagus* Yoshimoto (Hymenoptera: Encyrtidae)¹ (Kaya and Anderson, 1972, 1974a). Samples of elm spanworm eggs, larvae and pupae were collected from various areas of the outbreak from 1971–73, brought to the laboratory and reared to isolate and identify disease organisms and parasitoids. Incidence of parasitism of eggs by *O. ennomophagus* and *Telenomus alsophilae*² Viereck (Hymenoptera: Scelionidae) and larvae by *Actia ontario* Curran (Diptera:

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¹ Referred to as *Ooencyrtus* sp., *O. ennomus*, and *O. clisiocampae* (Ashmead) by the authors.

² May be new species (P. M. Marsh).

Tachinidae) have been published previously (Kaya and Anderson, 1972, 1974a; Anderson and Kaya, 1974a). The incidence of parasitism of the elm spanworm by other enemies and their chronological appearance, and a review of all reported parasitoids and diseases of this important but infrequent defoliator of hardwoods in eastern North America are reported herein.

METHODS

Collections of elm spanworm eggs and methods of determining parasitism were described by Kaya and Anderson (1972, 1974a), and collections and rearing methods of elm spanworm larvae were described by Anderson and Kaya (1974a). Prepupae and pupae collected in the field were kept individually in 1 oz cream cups. All larvae and pupae collected were kept until they died or until the adult elm spanworm or parasitoid emerged. If a parasitoid emerged, it was considered the sole cause of death. Incidence of parasitism by various parasitoids was determined. Larvae and pupae that died from causes other than parasitism were dissected and various organs examined with a phase contrast microscope for presence of disease organisms. Larvae were collected from 14 sites in 5 counties in 1972 and 4 sites in 4 counties in 1973. Pupae were collected from 11 sites in 4 counties in 1972 and 2 sites in 2 counties in 1973.

We were unsuccessful in rearing most tachinids to adults, thus identification was often based upon puparial characters. Incidence of parasitism by tachinids in this paper, with the exception of *A. ontario*, is recorded only to the probable genus.

RESULTS AND DISCUSSION

Egg parasitoids. The importance of *O. ennomophagus* and *T. alsophilae* during the outbreak in Connecticut has been reported by Kaya and Anderson (1972, 1974a) and Anderson and Kaya (1973a, 1974a). A third parasitoid, *Ablerus clisiocampae* (Ashmead) (Hymenoptera: Eulophidae), a species not previously recovered from the elm spanworm, was isolated from 3 of 6 egg masses collected at one site in May, 1972. Five of these egg parasitoids emerged from each of 2 egg masses and 3 emerged from the third egg mass. The egg masses were also parasitized by *O. ennomophagus* and *T. alsophilae*. Emergence holes in eggs verified that indeed this parasitoid emerged from the elm spanworm and not from some other insect that might have been on the bark. Inasmuch as over 200,000 eggs were examined during this study, *A. clisiocampae*, which has frequently been recovered from *Malacosoma* spp. (Lepidoptera: Lasiocampidae) (Witter and Kulman, 1972), is not considered to be an important parasitoid of the elm spanworm.

Larval and pupal parasitoids. No parasitoids were recovered from larvae collected in the first and second instars. A total of 363 1st and 2nd instars were collected from 5 sites in 1972, of which 208 died from unknown causes. Parasit-

oids were recovered from larvae collected in the 3rd and subsequent instars and from pupae. Fedde (1964) also reported that the late instars and pupae were attacked most frequently by parasitoids.

A previously unreported *Meteorus* sp. (Hymenoptera: Braconidae) was recovered from larvae collected in the 3rd through 5th instars from 2 sites in 1973. Parasitization was less than 1%.

Apanteles murtfeldtae Ashmead (Hymenoptera: Braconidae), a gregarious and previously unreported parasitoid of the elm spanworm, was recovered from larvae collected as 3rd, 4th and 5th instars. Hosts were killed in all of these instars. Parasitization was less than 2%.

Muscina stabulans (Fallen) (Diptera: Muscidae), a facultative parasitoid of lepidopterous larvae (Lewallen, 1952), but not previously reported as a parasitoid of the elm spanworm, was recovered from 4 5th-instar larvae. Up to 4 puparia were recovered from a single host.

Tachinids were the most frequently recovered parasitoids. They were isolated from larvae collected in the 3rd instar but most frequently in larvae collected in the 4th and 5th instars and from pupae. Parasitization was highest by *A. ontario* as reported by Anderson and Kaya (1974a) and shown in Table 1. Few host larvae collected in the 3rd instar were parasitized. Many 4th instars were parasitized by *A. ontario* and by tachinids which could not be identified. One 4th instar host larva was parasitized by *Eusisyropa*. Fifth instars were parasitized most frequently by *A. ontario*, to a lesser extent by *Eusisyropa* and rarely by *Winthemia* and *Euexorista* (Table 1). Hosts parasitized by *Eusisyropa*, *Winthemia* and *Euexorista* died as pupae. Parasitization by all tachinids was greater in 1973 than in 1972 and ranged as high as 64.3% in larvae collected in the 5th instar. Field collected pupae were primarily parasitized by *Eusisyropa*. Adults of *Euexorista futilis* (Osten Sacken) were obtained from elm spanworm pupae collected in 1971.

Two species of sarcophagids, *Boettcheria cimbicis* (Townsend), a previously unreported parasitoid of the elm spanworm, and *Sarcophaga houghi* Aldrich, were recovered. Parasitization by sarcophagids was usually less than 1% but reached 45% in one site. It is conjecture whether these sarcophagids are primary parasitoids or scavengers (Campbell, 1963).

Brachymeria intermedia (Nees) (Hymenoptera: Chalcididae), an introduced parasitoid of the gypsy moth, was recovered from pupae. Parasitization was less than 2%.

Single specimens of *Phaogenes mellinus* (Provancher) and *Aphanistes* sp., both previously unreported ichneumonid parasitoids of the elm spanworm, were recovered from pupae.

Astiphromma pectorale Ashmead (Hymenoptera: Ichneumonidae), possibly a hyperparasite of *Itopectis conquisitor* (Say) (Hymenoptera: Ichneumonidae), was isolated from 1 pupa of the elm spanworm.

The hyperparasite, *Brachymeria compsiluræ* (Crawford) (Hymenoptera: Chalcididae), was collected from several sites and found to parasitize the tachinids, *Winthemia*, *Eusisyropa*, *A. ontario* and *Euexorista*. Five of these hyperparasites were recovered from 5th instars, thereby showing that this hyperparasite is capable of finding its host within parasitized elm spanworm larvae. The majority, however, were recovered from elm spanworms collected as pupae. Parasitization of tachinid puparia from 5th instar elm spanworm ranged as high as 25% in one site. In collections comprised entirely of pupae, parasitization of puparia was as high as 19% in one location.

The chronology of parasitoid attack of elm spanworm larvae and pupae is shown in Table 1. Large numbers of 4th and 5th instars were parasitized on June 12, 1972. *A. ontario*, and to a lesser extent, *Eusisyropa*, were the predominant parasitoids. *A. ontario* parasitizes mainly 4th and 5th instars (Anderson and Kaya, 1974a), but it is not known if earlier instars were not parasitized because they are unsuitable hosts or if adult parasitoids were absent at that time. *A. ontario* continued to be abundant into the last of June, though parasitization gradually declined. Sarcophagids were most abundant during July. *B. compsiluræ*, a hyperparasite, did not appear in collections until the middle of June when larvae were predominantly in the 5th instar. Parasitization then remained at a fairly uniform level throughout the remainder of the season. This hyperparasite appeared shortly after tachinids became abundant in the samples. *I. conquisitor* and *B. intermedia* appeared only in the last pupal collection.

In 1973, collections did not begin until larvae were predominantly in the 4th and 5th instars during the week of June 7. Abundance of *A. ontario* reached a peak and *B. compsiluræ* appeared 1 week later than in 1972. *A. murtfeldtae* was recovered from larvae throughout June. *Meteorus* sp. appeared only in the June 7 collection. *I. conquisitor* was collected 2 weeks earlier in 1973 than in 1972.

Primary pathogens of larvae. Over 500 larvae were examined microscopically in 1972 and 1973 and none was found infected with a disease organism.

Parasitoids and diseases of the elm spanworm throughout its range. Many parasitoids have been recovered from the elm spanworm since Thompson (1945) catalogued its parasitoids. A complete list of the known parasitoids of the elm spanworm that we could find in the literature is given in Table 2. At least 42 primary parasitoids and 3 hyperparasites have been recorded. *O. ennomo-phagus* has been the most extensively studied parasitoid and offers the most promise for managing host populations (Anderson and Kaya, 1973a, b, 1974a, b, 1975; Kaya, 1972; Kaya and Anderson, 1972, 1974a, b, ms. in press).

There have been no verified published reports of isolations of naturally occurring disease organisms of the elm spanworm. Drooz (1965) reported the susceptibility of elm spanworm larvae to the fungus, *Pacilomyces farinosus*

TABLE 2. Insect parasitoids of the elm spanworm.

Family		Host stage attacked	Reference
HYMENOPTERA			
Encyrtidae	<i>Ooencyrtus ennomophagus</i> Yoshimoto ¹	Egg	Kaya and Anderson, 1972, 1974a, ms. in press; Anderson and Kaya, 1973a; Yoshimoto, 1975
Scelionidae	<i>Telenomus alsophilae</i> Viereck ²	Egg	Drooz, 1964; Ciesla, 1964a, 1965; Anderson and Kaya, 1973a, 1974a
	<i>Telenomus</i> sp.	Egg	Knull, 1932
Mymaridae	<i>Anagrus</i> sp.	Egg	Ciesla, 1964a
Eulophidae	<i>Ablerus clisiocampae</i> (Ashmead)	Egg	present paper
	<i>Euplectrus</i> sp.	Larva	Schaffner and Griswold, 1934
Braconidae	<i>Apanteles murtfeldtae</i> Ashmead	Larva	present paper
	<i>Meteorus</i> sp.	Larva	present paper
	<i>Rogas</i> sp. <i>Macrocentrus iridescens</i> French	Larva Larva	Raizenne, 1952 French, 1880
Ichneumonidae	<i>Apechthis picticornis</i> Cresson	Larva	Schaffner and Griswold, 1934
	<i>Glypta simplicipes</i> Cresson	Larva	Schaffner and Griswold, 1934
	<i>Hyposoter flavipes</i> Provancher	Larva	Schaffner and Griswold, 1934
	<i>Itoplectis conquisitor</i> (Say)	Larva, Pupa	Schaffner and Griswold, 1934; Ciesla, 1964b; Plumb and Friend, 1938; Knull, 1932; Davis, 1960; present paper
	<i>Casinaria geometrae</i> Walley	Unknown	Raizenne, 1952
	<i>Theronia atalantae</i> (Poda)	Pupa	Knull, 1932; Muesebeck et al., 1951
	<i>Aphanistes</i> sp.	Pupa	present paper
	<i>Phaeogenes mellinus</i> (Provancher)	Pupa	present paper
	<i>Pimplopterus</i> sp.	Unknown	Davis, 1960
	<i>Scambus hispae</i> (Harris)	Unknown	Davis, 1960; Muesebeck et al., 1951; Plumb and Friend, 1938
	<i>Astiphromma pectorale</i> Ashmead ³	Pupa	present paper
Chalcididae	<i>Brachymeria intermedia</i> (Nees)	Pupa	present paper
	<i>Brachymeria ovata</i> (Say)	Larva, Pupa	Fedde, 1964; Davis, 1960; Ciesla, 1964b
	<i>Brachymeria compsilurae</i> (Crawford) ⁴	Larva, Pupa	Knull, 1932; present paper
	<i>Brachymeria</i> sp.		Plumb and Friend, 1938
Pteromalidae	<i>Dibrachys cavus</i> (Walker) ⁴	Pupa	Plumb and Friend, 1938
DIPTERA			
Muscidae	<i>Muscina stabulans</i> (Fallen)	Larva	present paper
Sarcophagidae	<i>Boettcheria cimbicis</i> (Townsend)	Larva	present paper
	<i>Sarcophaga houghi</i> Aldrich	Pupa	Knull, 1932; present paper; Davis, 1960

TABLE 2. (continued)

Family	Host stage attacked	Reference
Tachinidae	<i>Sarcophaga aldrichi</i> Parker	Unknown Davis, 1962
	<i>Boettcheria latisterna</i> Parker	Unknown Knull, 1932
	<i>Helicobia rapax</i> (Walker)	Unknown Davis, 1960
	<i>Actia ontario</i> Curran	Larva Raizenne, 1952; Anderson and Kaya, 1974a; present paper
	<i>Actia</i> nr. <i>palloris</i> Coquillet	Larva Schaffner and Griswold, 1934
	<i>Compsilura concinnata</i> (Meigen)	Larva Schaffner and Griswold, 1934; Mc Guban and Coppel, 1962
	<i>Achaetoneura aletiae</i> (Riley)	Unknown Davis, 1960
	<i>Chaetogaedia analis</i> (Wulp)	Unknown Davis, 1960
	<i>Euphorocera floridensis</i> Townsend	Unknown Davis, 1960
	<i>Eusisyropa blanda</i> (Osten Sacken)	Larva Knull, 1932; Davis, 1960; Ciesla, 1964b; Schaffner and Griswold, 1934
	<i>Eusisyropa</i> sp.	Larva present paper
	<i>Xanthoernestia</i> sp.	Unknown Davis, 1960
	<i>Madremyia saundersii</i> Will	Larva Schaffner and Griswold, 1934
	<i>Euexorista futilis</i> (Osten Sacken)	Larva Schaffner and Griswold, 1934; present paper
	<i>Euexorista</i> sp.	Larva present paper
	<i>Phryxe vulgaris</i> (Fallen)	Larva Schaffner and Griswold, 1934
	<i>Winthemia</i> sp.	Larva present paper
	<i>Tachinomyia nigricans</i> (Webber)	Unknown Raizenne, 1952
<i>Blondelia eufitchiae</i> (Townsend)	Unknown Raizenne, 1952	
<i>Eusisyropa virilis</i> (Aldrich and Webber)	Unknown Aldrich and Webber, 1924	

¹ Referred to as *Ooencyrtus* sp., *O. ennomus* and *O. clisiocampae* by the authors.² May be an undescribed species (P. M. Marsh, personal communication).³ May be a hyperparasite of *Itopectis* (R. W. Carlson, personal communication).⁴ Hyperparasites.

(Dickson ex Fries) Brown and Smith, under laboratory conditions. Larvae are highly susceptible to commercial formulations of *Bacillus thuringiensis* Berliner applied either by ground spraying equipment or by plane (Dunbar and Kaya, 1972, and Dunbar *et al.*, 1973).

Viral diseases have been reported from the elm spanworm, but there is no clear evidence to substantiate their presence. Dietz (1925) reported a wilt disease in association with wet weather in elm spanworm larvae in Indiana. Karpel (1973) attributed the collapse of elm spanworm populations in New York to a virus epizootic. In the latter case, the elm spanworm outbreak overlapped into Connecticut in the early 1970s. We examined microscopically over 500 larvae in 1972 and 1973 and 2,000 larvae in 1971 (unpublished data), and

were unable to isolate or detect any viral infection in elm spanworm larvae. However, many larvae exhibited disease-like symptoms just before and after the larvae of the parasitoid, *A. ontario*, emerged from 4th and 5th instar hosts. Inasmuch as the causative organism was not isolated and identified and Koch's postulate not fulfilled, we don't believe the presence of viral diseases in the elm spanworm has been proven.

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